number of interim reports dealing with special subjects have been issued. These are incorporated in the general report, which was presented to Sir Albert Stanley in June, 1917. It will be seen, therefore, that the Committee completed its labours in about eleven months, and that a year has elapsed between the presentation and publication of its report. The latter is divided into fourteen sections, in regard to which limits of space permit reference to only two. It should be stated, however, that, generally speaking, the Committee failed to reach unanimity on most of the points discussed. Nearly all the interim reports are either signed with very decided reservations by certain members, or else accompanied by a minority report emphasising fundamental disagreement. It is true that the general summary of recommendations is signed by each member of the Committee, the numbers of which were reduced to nine by the death of Mr. Colville in December, 1916; but three of these, in doing so, direct attention to various dissenting statements of theirs in the body of the report. Sir Hugh Bell evidently came to very different conclusions from those reached by his brother employers, and has expressed them in a series of minority reports.

As regards what may be called the future position of labour in the industry, which is one of the most fundamental aspects of the problem, the sectional report is signed by five members, and more or less dissented from on three separate grounds by the remaining four. In the succeeding section, dealing with "Protection," the same five members recommend that the industry should be protected by the imposition of customs duties "upon all imported iron and steel and manufactures thereof," that a specific duty should be levied in each class of commodity, and that there should be maximum, general, and minimum tariffs. Messrs. Gavin and Hodge, while agreeing with this, consider it imperative that safeguards should be provided by the Government against the raising of prices unduly against the consumer and to the disadvantage of labour. On the other hand, Sir Hugh Bell and Mr. Davidson in their dissenting statement say:—"We entirely disagree with the foregoing report, which proposes to inflict on the community Protection in its most unmitigated form. Neither the grounds on which this course is recommended nor the means which it is proposed to adopt to accomplish it are, in our judgment, justified by the facts of the case. . . . A country of which the exports of iron and of the ultimate products of the manufacture of iron amount to more than one-third of the total value of the iron trade itself, and to something like one-quarter of the total export trade of the country, can by no stretch of language be described as not being self-sufficing." It will certainly not be easy to legislate on the basis of this report.

H. C. H. C.

NEW X-RAY TUBES.

THE war has brought about an activity in the production of the "Crookes" or X-ray tube that has become decidedly to our advantage. At the commencement of hostilities a certain amount of anxiety was felt as to how the great demand that was immediately created could be met; not only was the manufacture of these tubes rapidly falling into German hands, but we were also entirely dependent upon that country for the supply of the peculiar glass necessary for their construction. Happily the difficulties have now been overcome. The production of tubes of higher efficiency and excellence than was ever reached before the war has been achieved, and at the present time all the demands both for military and home needs can be met. This success is not confined to British manufacturers, but is shared by both our American and French Allies.

The invention by Dr. Coolidge in America of the ionic discharge tube has placed in the hands of the radiologist a highly efficient tool that will produce a volume of X-rays of any desired power of penetration. These tubes are supplied in England by the British Thomson-Houston Co., of Upper Thames Street.

Messrs. Watson and Sons, of Great Portland Street, W., are the sole agents for a very complete series of tubes produced by M. Pilon in France. These have been specially designed to meet military needs, and are beautifully constructed pieces of apparatus; some thousands of them have been supplied to the Allied Armies. There are also many excellent tubes of home construction that are being produced in London as rapidly as the present restricted labour conditions will allow. Of these we may mention the series known as the "Zenith" tubes, manufactured by Messrs. A. E. Dean and Co., of Holborn. In these tubes the new glass devised for the purpose by Sir Herbert Jackson is used, and they are London-made throughout.

Many other British-made tubes are on the market, so that there is thus every hope that another important industry has been saved from becoming a German monopoly.

THE POSITION OF UNIVERSITY AND HIGHER TECHNICAL EDUCATION.

I.—SUPPLY AND OUTPUT OF STUDENTS.

TWO of the chief subjects dealt with in the report of the Government Committee on the position of natural science in the educational system of Great Britain, of which a summary was given in NATURE of April 18, are (1) the need for concerted efforts to increase the number of students at universities and higher technical institutions with the view of securing a larger supply of trained scientific workers required for industrial and other purposes, and (2) that increased grants of public money are required to equip the universities for their work in pure and applied science, and to enable a substantial reduction of fees to be made. Few particulars are given in the report to show how the position of Great Britain as regards university and higher technical education compares with those of countries like Germany and the United States, though the evidence which such a comparison affords strengthens greatly the case presented. It may be worth while, therefore, to bring together some facts which accentuate the need and urgency of action in the directions indicated by Sir J. J. Thomson's Committee.

The first report (1915–16) of the Advisory Council for Scientific and Industrial Research pointed out that the prime condition of success for its operations was a largely increased supply of competent researchers. "Before the war," the report remarks, "the output of the universities was altogether insufficient to meet even a moderate expansion in the demand for research. The annual number of students graduating with first- or second-class honours in science and technology (including mathematics) in the universities of England and Wales before the war was only about 530, and of these but a small proportion will have received any serious training in research. We have frequently found on inquiry that the number of workers of any scientific standing on a given subject of industrial importance is very limited. . . .

"The responsibility for dealing with the grave situation which we anticipate rests with the education departments of the United Kingdom. We shall be able to do something to encourage a longer period of training by the offer of research studentships and the like; but that will not suffice. It is useless to offer scholarships if competent candidates are not forthcoming, and they cannot be forthcoming in sufficient numbers until a larger number of well-educated students enter the universities. That is the problem which the education departments have to solve, and on the solution of which the success of the present movement, in our opinion, largely depends."

Sir J. J. Thomson's Committee confirms the statement of the Advisory Council for Scientific and Industrial Research that the total annual output of the first- and second-class honours men in science and engineering for all the English universities is little more than 500. The total number of full-time men students who entered the universities and university colleges of England and Wales (excluding the medical schools) in the year 1913–14 was no more than 4400, and of these some hundreds were foreign students. It is estimated that nearly half this number were from the public schools, from which about 5200 leave annually at sixteen years of age or above, and 25 to 30 per cent. proceed to the universities. In the case of the State-aided secondary schools, the number leaving at sixteen years of age or above is approximately 8800; and the Government Committee estimates that from 12 to 15 per cent. pass to a university. This estimate is, however, probably too high, not more than about 10 per cent. of such students proceeding to universities. As a rule, the State-aided secondary schools devote more attention to science and other modern studies than do the public schools; and it is to them that we must chiefly look for an increased supply of university students to be trained as scientific workers.

In order to determine the position of the United Kingdom as regards education of a university standard in comparison with those of the United States and Germany, the conditions existing in the academic year 1913–14—that is, immediately preceding the opening of the war—have been analysed. The results show that much remains to be done to increase the number of university students from whom the supply of research workers must chiefly be drawn. The number of full-time students at the universities of the United Kingdom in 1913–14 was nearly 27,000, distributed as shown in Table 1.

1.—*Full-time Students at Universities of the United Kingdom*, 1913–14.

	Universities	Students
England	10	15,550
Scotland	4	7,550
Ireland	3	2,470
Wales	1	1,140
	18	26,710

In comparing the number of students attending universities and technical institutions of like rank in different countries, it is necessary, of course, to take population into account. Also, in making any exact comparison, the standard of the work at each university should be known. It is very difficult to derive these particulars from any published reports, but sufficient facts are available to enable a general comparison to be made. Table 2 shows the number of university students per 10,000 of population in the United States, Germany, and the United Kingdom. Students at technical institutions of university rank are included; and in the case of the United States only students in the seventy-two universities, colleges, and technical schools on the accepted list of the Carnegie Foundation for the Advancement of Teaching. If all students taking four-year courses at these institutions in the U.S.A. were included, the number and rate per 10,000 would be doubled.

2.—*Full-time Students at Universities and Higher Technical Institutions, and Ratio to Population.*

	Population	Students in Universities and Technical Institutions	Rate per 10,000
United States ...	100,000,000	100,000	10
Germany	65,000,000	90,000	13
United Kingdom ...	45,000,000	29,200	6
England	34,000,000	17,000	5
Scotland	4,800,000	8,000	16
Ireland	4,400,000	3,000	6
Wales	2,000,000	1,200	5

The number of students in universities and technical institutions of like rank may be taken as a rough index of national regard for intellectual equipment and high technical training. Judged by this standard, England and Wales occupy the lowest position among the countries represented in the foregoing table. Both in the United States and Germany there has been in recent years an increase in the number of university students far in excess of the increase of population, whereas before the war the reverse was the case in England and Wales. While industrial prosperity has been accompanied by an increase in the proportion of university students in the United States and Germany, the rate of increase of such students in England and Wales has diminished.

The number of collegiate and resident graduate students in universities and other institutions of university rank in the United States in 1913–14 was 210,500, made up of 139,400 men and 71,100 women. The number annually completing four-year courses and receiving bachelor degrees is about 26,000. In addition, in 1913–14 there were conferred 5250 graduate degrees and 520 doctorates of philosophy by examination.

The number of students in the twenty-one universities of Germany in 1913–14 was about 68,000, 58,000 of whom were matriculated students. The distribution of the students in the different faculties is shown in Table 3.

3.—*Number of Students in German Universities*, 1913–14.

	No. of Student
Faculty of Theology	5,840
,, ,, Jurisprudence, etc. ...	10,290
,, ,, Medicine	16,300
,, ,, Philosophy	25,780
Total matriculated students ...	58,210
Non-matriculated students ...	9,900
Grand total	68,110

In regard to the number of students receiving technological training of an advanced kind, the position of England and Wales is even worse than that shown by the proportion of university students. At the Imperial College of Science and Technology there were, in 1913–14, 700 such students; at Cambridge the number of candidates who presented themselves in the Natural Sciences Tripos, the Mechanical Sciences Tripos, and various special examinations in other branches of science was about 500; at Oxford the number of students of Natural Science was about 300; and at the Manchester College of Technology, 285. Most of the technical colleges in England and Wales are connected with the universities of their respective areas. Others provide technical institution courses approved by the Board of Education for students above seventeen years of age. Such provision for full-time education in applied science is, however, as the Board has pointed out, regrettably small in bulk compared with the needs for the industrial development of the country. In the year 1913–14 there were, in the twenty-six technical institutions recognised by the Board, fifty-four technological courses in engineering, chemistry, and subjects connected with the building, mining, textile, and leather trades, many of which were also attended by some students preparing for degrees; and five scientific courses mainly in provision for professional qualifications. The number of students taking the full courses was 1236, of whom 539 were in their first year, 374 in their second year, 269 in their third year, and 54 in later years of their courses. The numbers of full-time students of science and technology in all these universities and colleges are shown in Table 4.

4.—*Full-time Students in various Faculties of Science and Technology (excluding Medicine) in Universities and University Colleges in Receipt of State Grants* (1913–14).

	England	Wales
Pure science	1,620	234
Engineering, including naval architecture	1,085	44
Technology, including mining, metallurgy, and architecture ...	459	34
Agriculture, horticulture, and dairy work	221	58
	3,385	370

There are fifty-two agricultural and mechanical colleges for white students in the United States. These may be regarded as comparable with our technical institutions, and most of them are incorporated in universities. In these cases the students are included in the numbers given for universities. The number of undergraduate students in four-year college courses in the United States colleges of agriculture and mechanic arts in 1914 was 40,000; and the chief groups are shown in Table 5.

5.—*Students in Colleges of Agriculture and Mechanic Arts, U.S.A.*

	No. of Students
Agriculture, horticulture, and forestry ...	14,250
General science	4,360
Mechanical engineering	4,100
Civil ,, ...	3,480
Electrical ,, ...	3,280
General ,, ...	2,610
Chemical ,, ...	780
Mining ,, ...	680
Chemistry	610
	34,150

The number of degrees conferred in 1914 in agricultural and mechanical sciences were:—

	Agricultural Science	Mechanical Science
Bachelor degrees	1,900	1,960
Advanced ,, ...	150	150
	2,050	2,110

There are eleven technical high schools in Germany having the power of granting degrees. The number of students in these schools in 1913–14 was nearly 17,000, of whom 11,600 were fully qualified. It is not possible to make any exact comparison between the German technical universities and our technical institutions or the applied science faculties and departments of British universities. The matriculation for fully qualified students at the German technical high schools is the completion of the full nine years' secondary school course at a classical, semi-classical, or modern secondary school, and is practically equivalent in standard to a pass B.A. degree at one of our universities

In our own technical institutions the standard and age of admission are much lower, and if we count all the students at these institutions as well as those in applied science departments of universities the number is less than 5000, to compare with the 17,000 students in German technical high schools. In addition to these schools there are four agricultural high schools with 1750 students; five veterinary high schools with 1570 students; four forestry academies with 300 students; three mining high schools with 800 students, as well as other special schools; and in all these the educational qualifications for entrance are the same as at the technical and older universities.

Dr. F. Rose, a few years ago, made a detailed report to the London County Council upon technical education in the United Kingdom and Germany; and he showed that there are few technical institutions in the United Kingdom which can be compared with any of the great German technical universities. Good technical colleges and departments in England appear to be on a level with the best technical schools in Germany rather than with the technical universities. "Looked at," said Dr. Rose, "from the basis of the German standard of previous education and practical work, length, extent, and variety of the courses taken, and the number of diplomas granted, it will probably be found that there are insufficient students in the whole country to fill one of the large German technical universities"

II.—FINANCIAL PROVISION.

A comparison of the financial provision made for university and advanced technical training in the United Kingdom with what is available in the United States and Germany reveals our deficiencies just as decidedly as does that of the number of students. With the exception of Oxford and Cambridge, all the universities and university colleges in England and Wales participate in Parliamentary grants, the amounts of which, as well as other sources of income, are shown in Table 6.

6.—*Incomes of Universities and University Colleges in Receipt of Exchequer Grants* (1913–14).

	ENGLAND (18 Institutions)		WALES (4 Institutions)	
	Amount	Percentage of Total	Amount	Percentage of Total
Fees	£190,300	28·1	£17,600	27·2
Endowments ..	100,300	14·8	4,200	6·5
Donations and subscriptions	20,700	3·0	2,100	3·3
Annual grants from local authorities ..	108,500	16·0	3,800	5·9
Parliamentary grants ...	230,100	34·0	35,700	55·3
Contributions from hospitals, etc., for services rendered ...	1,500	0·2	—	—
Other income .	26,200	3·9	1,200	1·8
	£677,600		£64,600	
Grand total ...		£742,200		

It will be seen that the income from endowments of the eighteen universities and university colleges of England and Wales in receipt of Exchequer grants amounts to about 100,000*l*. Manchester receives about 23,000*l*.

annually from endowments, or 27·5 per cent. of its total income, whereas King's College, London, receives only 620*l*., or 1·6 per cent. of its income. Manchester University, Liverpool University, and University College, London, together have nearly half the total income from the endowments of the universities and university colleges in England which participate in the Exchequer grant.

In general, it may be said that these institutions derive about one-third of their total incomes from Parliamentary grants; the percentage of income from other sources varies so greatly that no general statement other than the averages given in the above table can be made.

In addition to the universities and university colleges in receipt of Exchequer grant, a number of medical schools and a few other institutions received in 1913–14 Parliamentary grants amounting to about 33,000*l*., or one-quarter of the total incomes. The total of the annual Parliamentary grants to these universities, colleges, and medical schools in England and Wales is about 300,000*l*. The grants are made up as shown in Table 7. Twenty-four institutions in all participate in the grant for technological and other professional (including medical) work, and ten of them are also in receipt of portions of the Exchequer grants to universities and colleges.

7.—*Heads under which Incomes from Parliamentary Grants are derived by Universities, University Colleges, and Medical Schools.*

	England	Wales
Exchequer	£170,000	£31,000
Board of Education, in respect of technological and other professional work	46,890	430
Board of Education, in respect of training of teachers	19,910	4,730
Board of Education, other grants	20,440	250
Other Government departments	19,560	4,780
	£276,800	£41,190

The financial provision made by the State for university, medical, and higher technical education in the United Kingdom is about 500,000*l*. annually. Of this amount England and Wales receive about 300,000*l*., Scotland about 84,000*l*., and Ireland about 100,000*l*. The total annual income of all the universities and university colleges in the British Isles, including the Universities and Colleges of Oxford and Cambridge, is about 2,000,000*l*.; that of universities and colleges in the United States is 20,000,000*l*., and of universities in Germany 1,800,000*l*. Particulars of the incomes of institutions in the United States are given in Tables 8 to 12.

8.—*Income of Universities, Colleges, and Technological Schools of the United States* (1913–14).

	Amount	Percentage of Total
For tuition and other educational services	£4,500,000	22·5
From invested funds	3,500,000	17·5
Donations and subscriptions	2,700,000	13·5
Grants from State or city	6,000,000	30·0
United States Government grant	1,000,000	5·0
Other sources	2,300,000	11·5
	£20,000,000	100·0

The incomes of individual universities in the United States are very high in comparison with those of most of our universities. Seventeen universities have each an annual income equal to, or in excess of, the total Parliamentary grants to universities and colleges of England and Wales, and nine have incomes equal to, or in excess of, the total Parliamentary grants to university and higher technical education in the whole United Kingdom. The incomes of these United States universities are shown in Table 9.

9.—*Annual Incomes of Seventeen Universities in the United States*, 1913–14.

University	Income
Cornell University	£1,300,000
Columbia ,,	1,300,000
Harvard ,,	860,000
Chicago ,,	660,000
Minnesota ,,	600,000
Wisconsin ,,	600,000
Illinois ,,	560,000
California ,,	500,000
Yale ,,	500,000
Michigan ,,	440,000
Northwestern University	300,000
Wellesley College, Mass.	300,000
Missouri University	300,000
Washington University, Missouri	300,000
Princeton University	300,000
Ohio State ,,	300,000
Pennsylvania ,,	300,000

Five States of the U.S.A., four of them with populations of about two millions each, gave grants to universities in 1913–14 exceeding the total Parliamentary grants to universities and colleges of England and Wales. These are shown in Table 10.

10.—*State Grants to Five Universities in the United States.*

State	Population	Grant
Minnesota	2,000,000	£500,000
Illinois	5,600,000	400,000
Wisconsin	2,300,000	400,000
California	2,400,000	300,000
Michigan	2,800,000	300,000

The benefactions to universities and colleges in the United States are similarly far in excess of those devoted to such institutions in the United Kingdom. The total amount of gifts and bequests to universities and colleges in the United States in the year 1913–14, excluding grants by the Federal Government, different States, and municipalities, was more than 5,000,000*l*. Of this amount nearly 4,000,000*l*. was for endowment, giving in a single year, if invested at 5 per cent., an increased endowment income of 200,000*l*., or double the income derived from all the endowment funds of the whole of the modern universities and university colleges of England and Wales. The chief gifts in 1913–14 are shown in Table 11. In addition, forty-five universities, colleges, and technological schools each received gifts above 20,000*l*.

11.—*Private Benefactions to Universities of the United States*, 1913–14.

University	Benefactions
Cornell University	£800,000
Harvard ,,	400,000
Chicago ,,	300,000
Yale ,,	200,000
Washington ,,	200,000
Columbia ,,	200,000

The gifts and bequests to universities and colleges in the United Kingdom in the year 1913–14 amounted to about 200,000*l*.

The incomes of the colleges of agriculture and mechanic arts in 1913–14, excluding the grants for experiment stations, amounted to 7,000,000*l.*, made up as shown in Table 12.

12.—*Incomes of Agricultural and Technical Colleges, U.S.A.*

Sources	Amount	Per cent.
From States	£3,600,000	52
Federal Government ...	700,000	10
Tuition fees and endowments	2,700,000	38
	£7,000,000	100

The total income of these technical colleges is thus nearly ten times that of the whole of the universities and colleges in England and Wales in receipt of Exchequer grants; and 60 per cent. is derived from State or Federal grants in comparison with 40 per cent. from Parliament and local authorities combined in the case of universities and colleges of England. It may be added that the normal State expenditure per annum on higher agricultural education in England and Wales is about 20,000*l.*, and 35,000*l.* for agricultural research, or not much more than a single State in America receives for similar purposes.

The incomes of twenty-one German universities in 1913–14, not including the technical high schools, amounted to nearly 1,800,000*l.*; and of this the State provided 1,500,000*l.*, or more than 80 per cent. of the total. The universities with incomes approaching 100,000*l.* or more are shown in Table 13.

13.—*Incomes of Eight German Universities.*

University	Income	State grants	Per cent.
Berlin	£246,000	£205,000	81
Leipzig ...	231,000	190,000	82
Breslau ...	112,000	82,000	73
Halle	111,000	74,000	67
Bonn	100,000	75,000	75
Kiel	99,000	65,000	66
Göttingen ...	94,000	50,000	53
Königsberg ...	92,000	72,000	80

Some of the points brought out by the foregoing tables may be stated as follows:—

(1) In proportion to population, the United States has more than twice as many students of university standard as are in England; Scotland has more than three times as many; and Germany nearly three times as many.

(2) There are only 5000 full-time students of science and technology in the United Kingdom in comparison with nearly 17,000 in Germany and 34,000 in the United States.

(3) The total income of universities in the United States amounts to about 20,000,000*l.*, and that of Germany to nearly 1,800,000*l.* The total income of all the universities of the United Kingdom is about 2,000,000*l.*

(4) Eighty per cent. of the total income of German universities is derived from State grants, in comparison with 34 per cent. contributed in Parliamentary grants to the modern universities of England and Wales.

(5) Thirty per cent. of the income of universities in the United States is derived from invested funds and donations, in comparison with 15 per cent. in the modern universities of England and 6 per cent. in those of Wales.

(6) The tuition fees at universities of the United Kingdom form a much higher percentage of the total income than they do in the United States and Germany.

(7) Nine universities in the United States have individual incomes exceeding the total amount granted annually by Parliament to universities and institutions of like standard in the United Kingdom.

(8) Five States of the United States give grants to their universities exceeding the amount of the Parliamentary grants to universities and colleges of England and Wales.

(9) Private benefactions to universities and colleges in the United States amount to more than 5,000,000*l.* annually; in the United Kingdom they do not average one-twentieth that sum.

(10) The colleges of agriculture and mechanic arts in the United States have a total income of 7,000,000*l.*, or ten times that of the whole of the modern universities of England and Wales.

(11) The University of Berlin receives annually from State funds a grant nearly equal to the total annual Parliamentary grants to the universities and colleges of England and Wales.

It will be evident from these facts that in the domain of higher education the United Kingdom compares very unfavourably with the United States and Germany. No doubt one reason for this is that in America and Germany there has been a greater demand for highly trained men than in the British Isles, where posts for such men have been few, salaries low, and prospects poor. Conditions are, however, improving; and the industrial research associations being formed in connection with the Department of Scientific and Industrial Research, as well as associations established on the lines suggested by the Whitley Report, need for their successful operation the employment of men capable of undertaking research. The conditions of industrial development and the competition of other countries make it essential to secure an adequate supply of trained workers of this type.

Increased grants to universities and technical institutions are needed to enable the tuition fees to be reduced and to ensure that the staffs are paid salaries commensurate with the high qualifications demanded. The present aid given by Parliament is in no way adequate to modern needs, and compares very unfavourably with what is available in the United States and Germany. The grand total of all Parliamentary grants to universities and technical colleges of university rank in the United Kingdom is about 500,000*l.*, whereas the Federal and State grants in the United States amount to 7,000,000*l.*, and in Germany to nearly 2,000,000*l.* The provision made by Parliament for higher education is thus obviously not that which should be expected of a State which intends to maintain its position among leading Powers. R. A. GREGORY.

SCIENTIFIC ORGANISATIONS OF THE ALLIED NATIONS.

AT the invitation of the Royal Society, a conference between representatives of the Allied nations will be held in London on October 9 to discuss the future conduct of scientific organisations. It is expected that representatives from the academies of Paris, Rome, Tokyo, and Washington, as well as nominees of the Governments of Belgium, Portugal, and Serbia, will attend. A memorandum proposed by a committee of the Royal Society points out that international scientific organisations and conventions may be divided into four groups, according to their objects and methods of procedure. A first group consists of those important agreements which fix the standards of measurements, and are essential not only in purely scientific investigations, but also in the development of many industries. A second group contains associations definitely formed for the investigation of scientific problems in which co-ordination of observation is essential. A third group, which hitherto has not been large in numbers, but presents some special features, embodies the efforts to organise undertakings that might be carried out in one locality,